

# **RAPID HYDROGRAPHIC, OPTICAL AND MICROSTRUCTURE SURVEYS ON THE CONTINENTAL SHELF AND SLOPE**

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## **LONG-TERM GOALS**

To understand the dynamics of mesoscale circulation over the continental shelf and slope, with an emphasis on fronts, jets, eddies and topographic influences. To examine the relationship between circulation processes and the spatial distributions of mixing and optical properties over the continental margin.

## **OBJECTIVES**

To investigate the relationship between mesoscale circulation and spatial distributions of mixing and optical properties over the continental shelf and slope. To understand how lateral variations in the density, velocity, mixing and optical fields influence variations in vertical mixing processes observed at a single mid-shelf location. Specific objectives of this project are: to determine the characteristics and spatial scales of mixing and optical properties on the continental shelf and slope in the Middle Atlantic Bight south of Marthas Vineyard; to investigate how distributions of mixing and optical properties depend on characteristics of the mesoscale coastal circulation; to describe how the characteristics and distributions of mixing and optical properties on the shelf differ between seasons and relate these differences to seasonal contrasts in coastal circulation and water-column structure.

## **APPROACH**

As part of the Coastal Mixing and Optics (CMO) Accelerated Research Initiative, we made contemporaneous measurements of density, light absorption/attenuation and microstructure using sensors mounted on SeaSoar, a towed undulating measurement platform. The SeaSoar sensor suite includes a dual-sensor Sea-Bird CTD, a nine wavelength spectral absorption and attenuation meter (WET Labs ac9) and a new microstructure instrument (MicroSoar). Horizontal velocity is measured using a 300-kHz shipborne acoustic Doppler current profiler (ADCP). We conducted rapid surveys using R/V Endeavor during two 21-day field experiments in the Middle Atlantic Bight centered near 40.5N, 70.5W, south of Marthas Vineyard (Figure 1). We completed a summer survey, when the shelf is stratified, from 14-Aug to 1-Sep 1996 and a spring survey, when the shelf water tends to be more mixed, from 25-Apr to 15-May 1997. During each field experiment we collected data from repeated large-region surveys over a roughly 70 x 80 km box completed in about 2 days. Alternating with the large-region surveys, measurements were concentrated in a small box (roughly 25 x 25 km completed in 14 hours) centered around a mid-

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shelf location where the physical and optical fields were intensively sampled by our CMO colleagues using moored instrumentation and vertical profiling from a stationary ship.

## WORK COMPLETED

From 25-April to 15-May 1997 we conducted rapid SeaSoar surveys of the CMO region south of Marthas Vineyard (Figure 1). Three sampling strategies were employed: large-area, 70x80 km shelf-slope surveys to define regional distributions; small-area 25x25 km boxes centered on a moored array in 70-m of water and also the location of concurrent vertical profiling conducted from the stationary R/V Knorr; and a butterfly survey pattern with a leg along the 70-m isobath to define scales of variability alongshore. In total

we occupied the large-area grid two times and the small-box grid eleven times. This number of grid occupations is similar to our effort in Aug-Sep 1996, when we occupied the large-area grid three times and the small-box grid nine times. We successfully flew an ac9 optical instrument on SeaSoar during the two 21-day CMO cruises. An initial look at the Aug-Sep 1996 optical data

CMO cruise onboard R/V Endeavor from 25-April to 15-May 1997

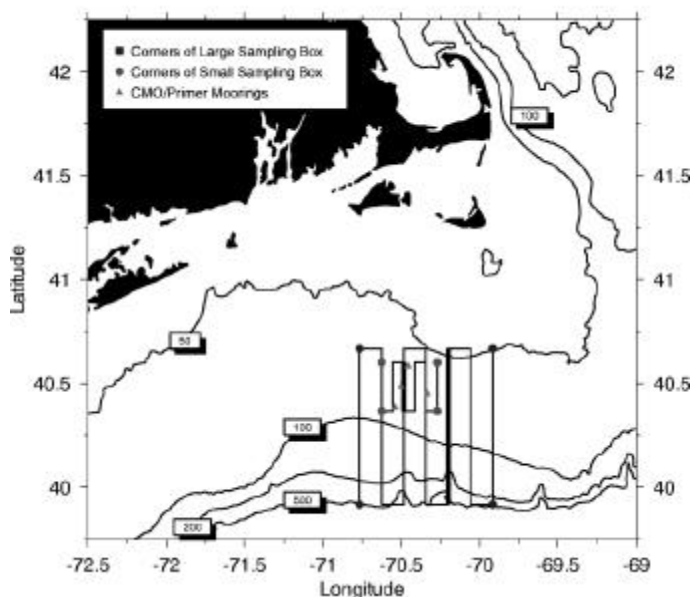


Figure 1. Location map showing the Coastal Mixing and Optics study region and SeaSoar sampling patterns. Data from two cross-shelf transects (highlighted with thick lines) are shown in Figures 2 and 3.

set has been presented (Barth and Kosro, 1997). Techniques to process the optical data, including applying a

time-dependent lag between the optical and physical data sets, have been developed and a paper describing the ac9-on-SeaSoar technique is nearly ready for submission (Barth and Bogucki, 1997). We continue to develop a system to integrate data communication and power for all the sensors onboard SeaSoar by installing a WET Labs Modular Ocean Data and Power System Plus (MODAPS+) in SeaSoar. The MODAPS+ provides power for the CTD, ac9 and MicroSoar and returns an integrated data stream to topside computers.

We have developed, tested, and flown MicroSoar, an instrument for making fine-resolution temperature and conductivity measurements from SeaSoar (Dillon et al., 1996; May, 1997). This effort is being led by Tom Dillon at OSU and was begun with a NSF Small Grant for Exploratory Research (SGER) to Dillon and Barth. The MicroSoar is powered and returns data via the MODAPS+. MicroSoar is equipped with a rugged microconductivity probe capable of withstanding stresses introduced during SeaSoar flight. MicroSoar is also equipped to sample vehicle accelerations along three axes. MicroSoar was flown aboard SeaSoar during the Aug-Sep 1996 and the Apr-May 1997 CMO cruises. Analysis of the high-frequency temperature, conductivity and acceleration data is underway.

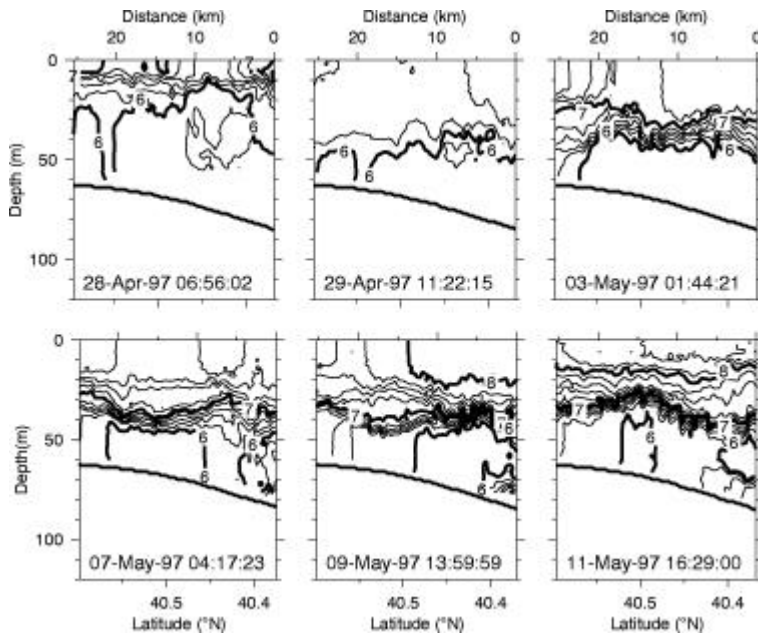
## RESULTS

The rapid SeaSoar surveys reveal much structure in both the vertical and horizontal distributions of hydrographic, velocity and optical properties. Repeated sections and maps show the evolution of the water column under the influence of surface forcing and advection. In Figure 2, a time series of cross-shelf temperature sections from the spring 1997 CMO cruise is shown. The section is from along the longitude (70.5 W) of the CMO central site (at 40.5 N) (Figure 1). Data from the SeaSoar CTD have been averaged into 2-m vertical bins and 0.5 km alongtrack bins. A 30+ knot storm mixed the water column during the latter half of 28 April. After 30 April a strong thermocline is formed near 40 m depth. Horizontal structure comes from: a relatively warm (and fresh as evident from salinity sections, not shown), shallow lens of water entering the region from the inshore side before 3 May; an intrusion from offshore of warm (and salty as evident from salinity sections, not shown) slope water near the bottom on 9 May; and short-scale variability on the thermocline, for example on 9 and 11 May. Analysis is planned to quantify these observed changes in water column structure given the surface forcing and advective influences. The spring cruise captured nicely the beginning of the establishment of the seasonal thermocline (and hence pycnocline) over the shelf in the Middle Atlantic Bight.

Longer cross-shelf sections that include the CMO central region, but extend out past the shelf break, establish the regional hydrography and velocity fields.. In Figure 3, a cross-shelf hydrographic section along 70.2W as measured with SeaSoar during the Coastal Mixing and Optics spring 1997 cruise is shown. Again, data from the SeaSoar CTD have been averaged into 2-m vertical bins and 0.5 km alongtrack bins. Notable features are: a shelfbreak front separating warm, salty slope water from cold, fresh shelf water; relatively homogeneous salinity in the upper water column over the shelf; a warm upper layer over the shelf separated from the cold pool below by a seasonal thermocline in the early stages of development; and a long extension of slope water up the shelf in a bottom boundary layer. Analysis of this long, thin piece of slope water using multiple cross-shelf sections and the ADCP velocity fields is underway. We plan to investigate the dynamics responsible for moving slope water up the shelf near the bottom. The presence of this warm, salty, near-bottom water is certainly important for the evolution of the cold pool just above. There is also a doming evident in the isosurfaces offshore associated with the shelfbreak front. Again, by using multiple cross-front sections we are examining alongfront variability (meanders, eddies) of the shelfbreak front. Lastly, the SeaSoar observations reveal much short-scale (1-2 km) variability in the temperature and salinity fields associated with the shelfbreak front including possible internal solitons and strong, density-compensated T and S fronts.

## IMPACTS/APPLICATIONS

By combining the simultaneous measurement of hydrography, velocity, optical properties and fine-scale temperature variance from over the continental margin, we expect to make progress understanding the dynamics of the interactions between these fields. Understanding processes will lead to a greater predictive capability for specifying the distributions and their time-dependent behavior over the continental margin.



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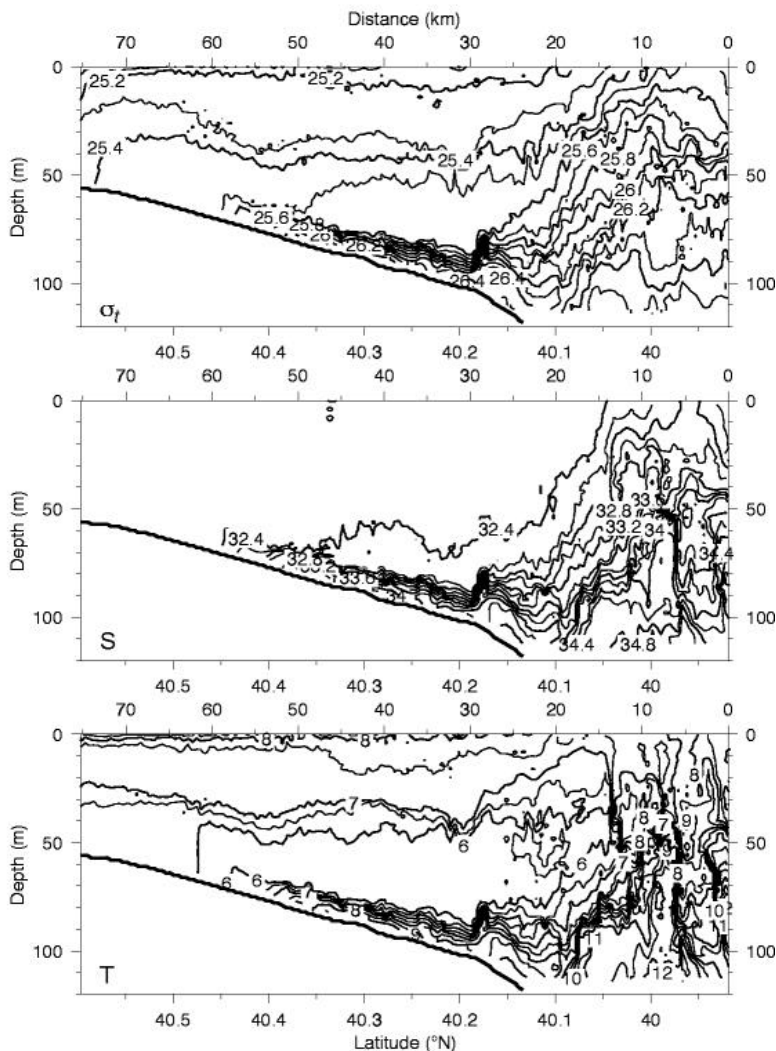


Figure 2. Time series of cross-shelf temperature sections along 70.5N as measured with SeaSoar during the Coastal Mixing and Optics spring 1997 cruise. Data from the SeaSoar CTD are averaged into 2-m vertical bins and 0.5 km alongtrack bins. A 30+ knot storm mixed the water column during the latter half of 28 April. After 30 April a strong thermocline is formed near 40 m depth. Horizontal structure comes from: a relatively warm, shallow lens of water entering the region from the inshore side before 3 May; an intrusion from offshore of warm slope water near the bottom on 9 May; and short scale variability on the thermocline, for example on 9 and 11 May.

Figure 3. Cross-shelf hydrographic section along 70.2W as measured with SeaSoar during the Coastal Mixing and Optics spring 1997 cruise. Data from the SeaSoar CTD are averaged into 2-m vertical bins and 0.5 km alongtrack bins. Notable features are: a shelfbreak front separating warm, salty slope water from cold, fresh shelf water; relatively homogeneous salinity in the upper water column over the shelf; a warm upper layer over the shelf separated from the cold pool below by a seasonal thermocline in the early stages of development; and a long extension of slope water up the shelf in a bottom boundary layer.

## **TRANSITIONS**

The MicroSoar technology is being packaged for use by Ron Zaneveld on his optical profiling package. The MODAPS+ data acquisition and power supply system is being used by other groups (T. Cowles, OSU; C. Roesler, UConn) and is available from WETLabs for use by other interested parties.

## **RELATED PROJECTS**

We will collaborate with our CMO colleagues who are using moored instrumentation and vertical profiling from a stationary ship to address the goals of the ARI. The overall success of the program relies on being able to separate local mixing dynamics and their effects on optical property distributions from advective effects influenced by mesoscale coastal circulation. We also plan to work with scientists participating in the ONR PRIMER "Synthetic Aperture Sonar" conducting operations near the CMO central site.

J. Barth and P. M. Kosro have been funded under a DURIP grant to purchase instrumentation to measure ocean currents and seawater properties (temperature, salinity and pressure) from a small research vessel. A CTD will be cycled through the water column using a small, towed undulating instrument and velocities will be measured with a shipboard ADCP. We are also working with a manufacturer to produce surface drifters capable of measuring very near-surface current velocities with high precision. The technique involves application of a Wide-Area Differential GPS technique (Pierce et al., 1997). The instrument suite will enable the collection of high-quality oceanographic data over the mid- and inner continental shelf from small, relatively inexpensive and flexibly-scheduled research vessels. We will use the small-boat instrumentation and a shallow-water mooring to investigate the physics of the inner shelf. We will also use the instrument suite to provide ground truth for surface velocity measurements made remotely from a land-based radar system, and to extend those measurements below the ocean surface. The combined measurements will be used to characterize and investigate the origin of vertical shear in upper-ocean horizontal velocities.

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[http://streak.oce.orst.edu/puc\\_sections.html](http://streak.oce.orst.edu/puc_sections.html)